

PLASMA DENSITY INFORMATION MEASURING METHOD, PROBE USED FOR  
MEASURING PLASMA DENSITY INFORMATION, AND PLASMA DENSITY  
INFORMATION MEASURING APPARATUS

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BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to: a plasma density information measuring  
method in plasma used in a producing process of a thin film component, a particle beam  
source or an analysis apparatus; a probe for measuring the plasma density information  
used for measuring the plasma density information; and a plasma density information  
measuring apparatus; and more particularly, to a technique for easily measuring the  
plasma density information over the long term.

(2) Description of the Related Art

In recent years, the use of plasma is increased. In a producing process of a  
thin film component, using high-frequency plasma generated by high-frequency power  
(high-frequency electric power) in a range from a RF frequency band of about 10 MHz  
to a micro frequency band of 2.45 GHz, etching process or CVD (chemical-vapor  
deposition) are conducted. In such a plasma application technique, it is extremely  
important for conducting appropriate process to sufficiently grasp the information  
concerning plasma density which excellently shows the characteristics of generated  
plasma. In the case of typical plasma comprising monovalent positive ion and electron,  
the positive ion density and the electron density are substantially equal to each other due  
to the properties particular to plasma that electrically neutral state is maintained, the  
electron density is generally called as plasma density.

Conventionally, as a method for measuring the electron density in plasma, there

is an electron beam irradiation type plasma vibration probe which was developed relatively recently, in addition to a Langmuir/probe method and a microwave interference measuring method.

The Langmuir/probe method is a method in which a metal probe is directly exposed in plasma in this state, direct current bias voltage, or direct current bias voltage on which high-frequency voltage is superposed is applied to the metal probe, and based on the current value flowing through at that time, electron density is measured.

The microwave interference measuring method is a method in which a chamber for generating plasma is provided with windows which are opposed to each other with plasma positioned therebetween, microwave (e.g., single color laser light) is radiated to the plasma through one of the windows, and the microwave ejected from the other window is detected, and electron density is obtained based on phase contrast between the radiated microwave and ejected microwave.

The electron beam irradiation type plasma vibration method is a method in which a hot filament is placed in a chamber, and based on frequency of plasma oscillations generated when electron beam is irradiated to the plasma from the hot filament, electron density is obtained.

However, when the Langmuir/probe method is used for reactive plasma, there is a problem that the measuring can not be continued for a long time (i.e., life time is short). This is because that stains comprising insulative films are adhered on a measured metal probe within a short time, the current value flowing through the metal probe is varied, and accurate measurement can not be continued soon. In order to remove the stains adhered on the metal probe surface, a method in which negative bias voltage is applied to the metal probe to carry out sputter-removing method using ion, and a method in which the metal probe is allow to glow to evaporate and remove the

stains have been attempted, but the effect is poor, and the problem is not solved by these methods.

Further, the microwave interference measuring method has a problem that the measurement can not be conducted easily. This is because a large-scale and expensive apparatus and adjustment of microwave transmission path are necessary, the phase contrast between the radiated microwave and ejected microwave is small and thus, it is difficult to measure precisely. Further, in the case of the microwave interference measuring method, there are drawbacks that only the average density can be obtained, there is no spatial resolution.

Furthermore, in the case of the electron beam irradiation type plasma vibration probe method, in addition to anxiety of plasma atmosphere contamination due to tungsten which is evaporated from the hot filament, there is a problem of anxiety of interruption of measurement caused by break of hot filament. Especially in the case of plasma using oxygen or chlorofluorocarbons gas, the hot filament is easily cut or broken, and it is necessary to frequently exchange the filament, it can not be said that this is practical.

#### SUMMARY OF THE INVENTION

In view of the above circumstances, it is an object of the present invention to provide a plasma density information measuring method capable of easily measuring the plasma density information over the long term, a probe for measuring the plasma density information, and a plasma density information measuring apparatus.

To achieve the above object, the present invention provides the following structure.

That is, a plasma density information measuring method of the present invention comprises the steps of: